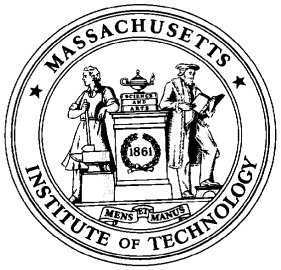
Roadmapping the Communications Value Chain



Massachusetts Institute of Technology
Sloan School of Management

One View of the Communications Value Chain

MATERIALS & PROCESS EQUIP	COMP-ONENTS	EQUIPMENT MAKERS	NETWORK OWNERS	SERVICE PROVIDERS	CONTENT & APPLICS	DEVICES	END USERS
•Silicon •Gaas •InP •Polymers •Steppers •Etchers •MEMS •Insertion •Etc..	•Lasers •Amplifiers •Transceiver •Filters •Processors •Memories •Fiber •ASICS •MEMS •DSP's •Etc..	•Routers •Switches •Hubs •Base Stations •Satellites •Servers •Software •O/S •Etc..	•Wireless •Backbone •Metro •Access •Substations •Satellites •Broadcast Spectrum •Communic Spectrum •Etc..	•Long distance •Local Phone •Cellular •ISP •Broadcast •Hot Spots •Cable TV •Satellite TV •VPN's •MVNO's •Etc..	•Music •Movies •Email •VoIP •POTS •Shopping •ERP •SCM, CRM •Surveillance •eBusiness •Etc..	•Computers •Phones •Media Players • Cameras •PDA's •Weapons •Etc..	•Business •Consumer •Gov't •Military •Education •Medical •Etc..

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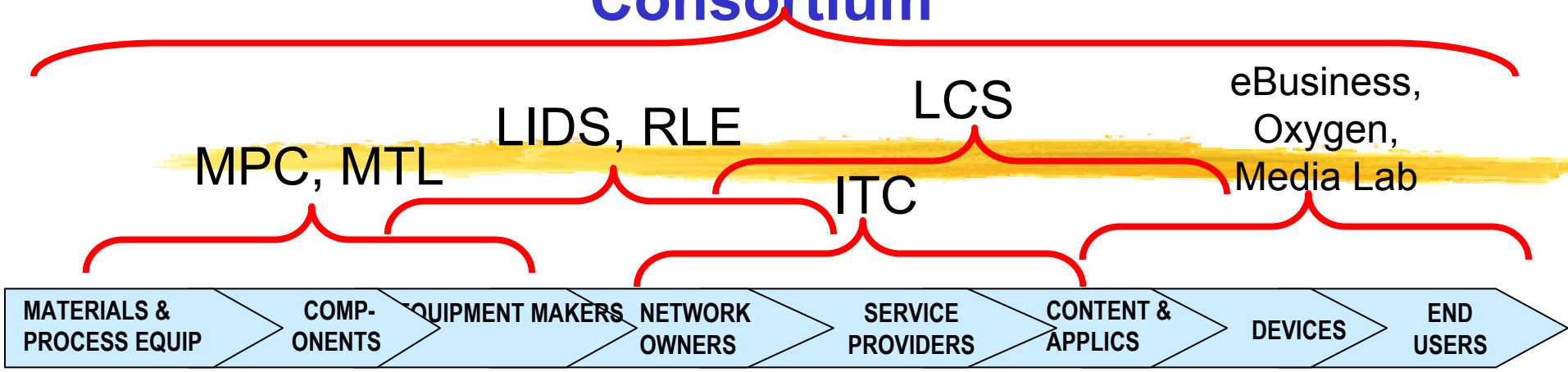
Access Architecture

Proposed MIT Communications Roadmap Consortium



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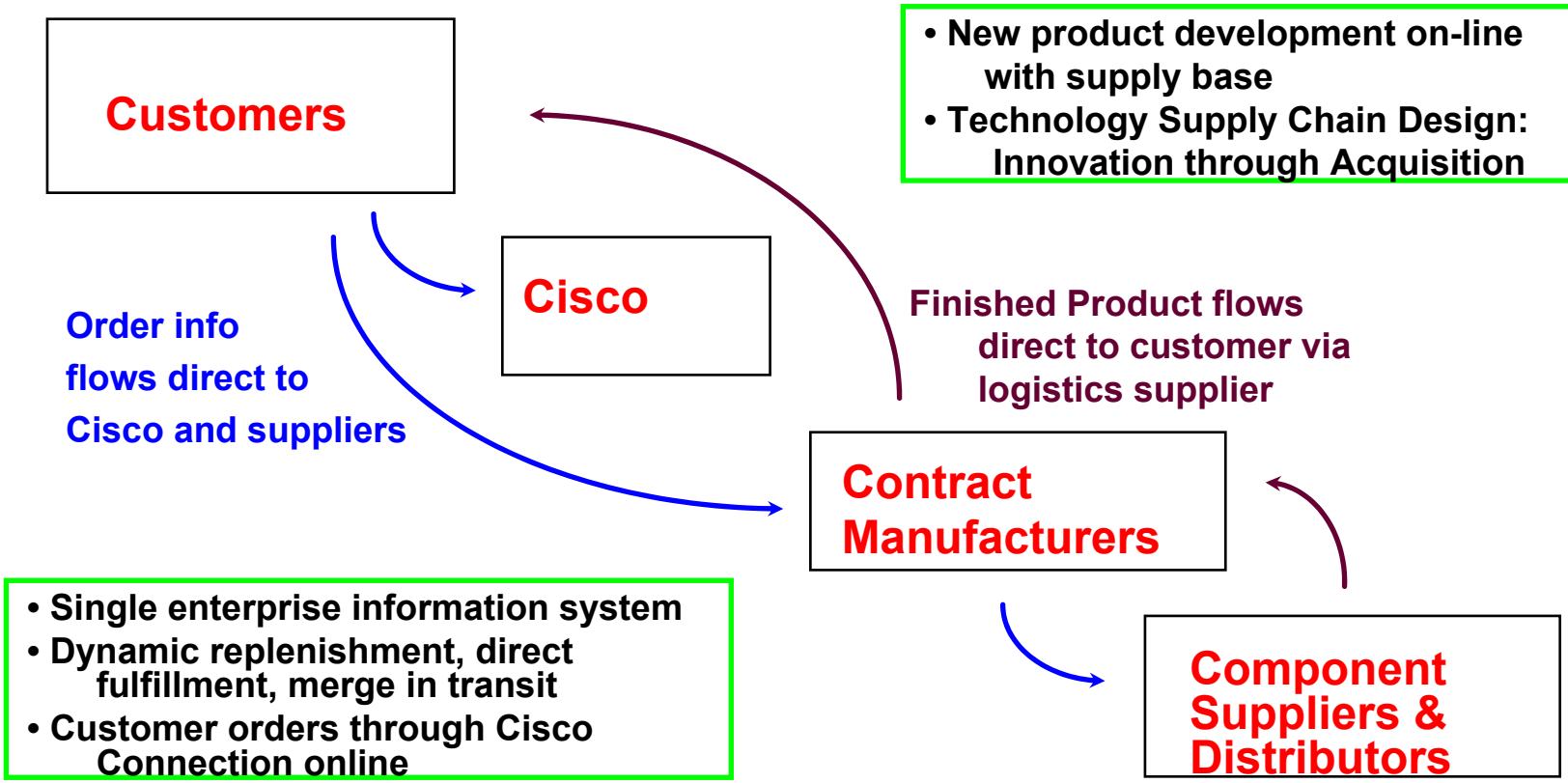
Access Architecture

Prof. C. Fine, MIT

Roadmap Components: Dynamic Analyses

1. Business cycle dynamics
   (e.g., systems dynamics-like models of the bullwhip effect)
2. Industry structure dynamics (e.g., double helix in *Clockspeed*)
3. Corporate strategy dynamics (e.g., dynamic strategic analyses for players in the value chain)
4. Technology dynamics (e.g., the Semiconductor Industry Assoc. roadmap built around Moore's law)
5. Regulatory Policy Dynamics
   (Cross-National, Cross Sector)

Cisco's End-to-End Integration for its Fulfillment Supply Chain



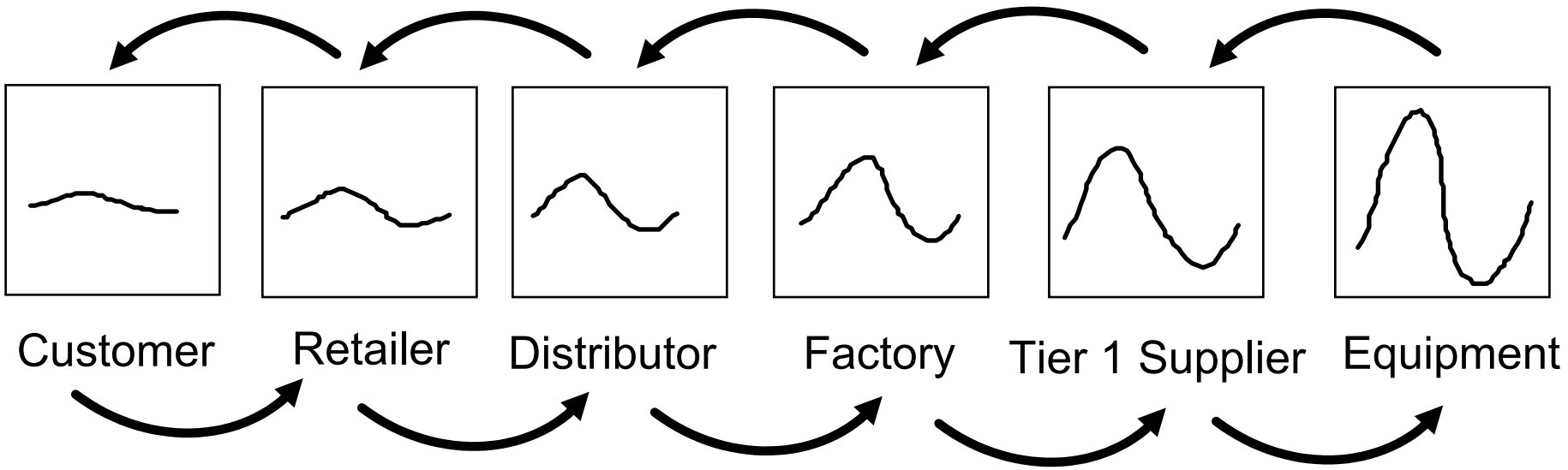
Basic Design Principle: Arm's length Relationship with Fulfillment Chain Partners

Cisco's Strategy for Technology Supply Chain Design

1. Integrate technology around the router to be a communications network provider.
2. Leverage acquired technology with
   - sales muscle and reach
   - end-to-end IT
   - outsourced manufacturing
   - market growth
3. Leverage venture capital to supply R&D

Basic Design Principle: Acquisition Relationship with Technology Chain Partners

Volatility Amplification in the Supply Chain: *"The Bullwhip Effect"*



Information lags
Delivery lags
Over- and underordering
Misperceptions of feedback
Lumpiness in ordering
Chain accumulations

SOLUTIONS:
Countercyclical Markets
Countercyclical Technologies
Collaborative channel mgmt.
(Cincinnati Milacron & Boeing)

Supply Chain Volatility Amplification: Machine Tools at the tip of the Bullwhip

- - -

"We are experiencing a 100-year flood." J. Chambers, 4/16/01

See "Upstream Volatility in the Supply Chain: The Machine Tool Industry as a Case Study," E. Anderson, C. Fine & G. Parker *Production and Operations Management,* Vol. 9, No. 3, Fall 2000, pp. 239-261.

LESSONS FROM A FRUIT FLY:
CISCO SYSTEMS

1. KNOW YOUR LOCATION IN THE VALUE CHAIN
2. UNDERSTAND THE DYNAMICS OF VALUE CHAIN FLUCTUATIONS
3. THINK CAREFULLY ABOUT THE ROLE OF VERTICAL COLLABORATIVE RELATIONSHIPS
4. INFORMATION AND LOGISTICS SPEED DO NOT REPEAL BUSINESS CYCLES OR THE BULLWHIP.

Bonus Question:

How does clockspeed impact volatility?

Roadmap Components: Dynamic Analyses

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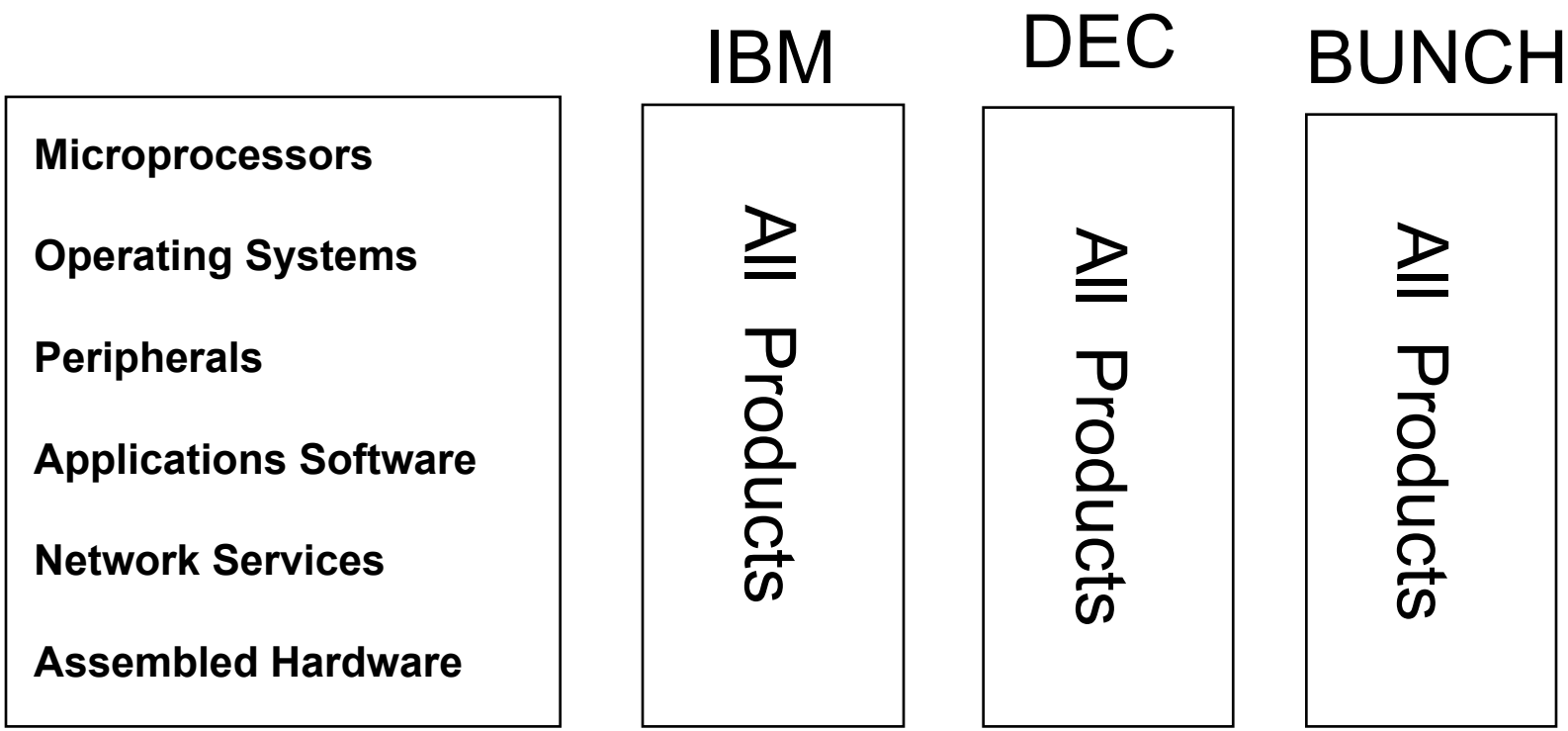
Vertical Industry Structure with *Integral* Product Architecture

Computer Industry Structure, 1975-85



(See A. Grove, Intel; and Farrell, Hunter & Saloner, Stanford)

Horizontal Industry Structure with *Modular* Product Architecture

Computer Industry Structure, 1985-95

Microprocessors	Intel | **Moto** | **AMD** | **etc**
Operating Systems	Microsoft | Mac | Unix
Peripherals	HP | Epson | Seagate | **etc** | **etc**
Applications Software	Microsoft | Lotus | Novell | etc
Network Services	AOL/Netscape | Microsoft | EDS | etc
Assembled Hardware	HP | Compaq | IBM | Dell | etc

(See A. Grove, Intel; and Farrell, Hunter & Saloner, Stanford)

THE DYNAMICS OF PRODUCT ARCHITECTURE AND VALUE CHAIN STRUCTURE:

THE DOUBLE HELIX

See Fine & Whitney, "Is the Make/Buy Decision Process a Core Competence?"

Roadmap Components: Dynamic Analyses

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ALL COMPETITIVE ADVANTAGE IS TEMPORARY

Autos:

Ford **in 1920,** ***GM*** **in 1955,** ***Toyota*** **in 1990**

Computing:

IBM **in 1970,** ***DEC*** **in 1980,** ***Wintel*** **in 1990**

World Dominion:

Greece **in 500 BC,** ***Rome*** **in 100AD,** ***G.B.*** **in 1800**

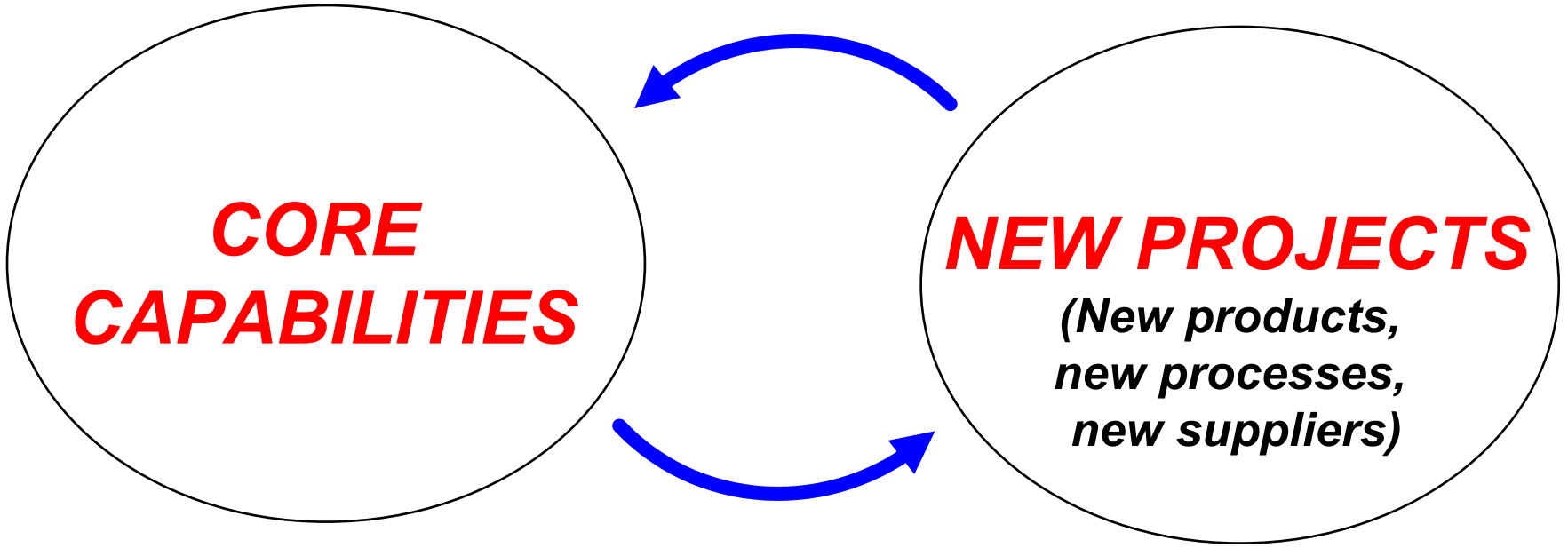
Sports:

Bruins **in 1971,** ***Celtics*** **in 1986,** ***Yankees*** **no end**

The faster the clockspeed, the shorter the reign

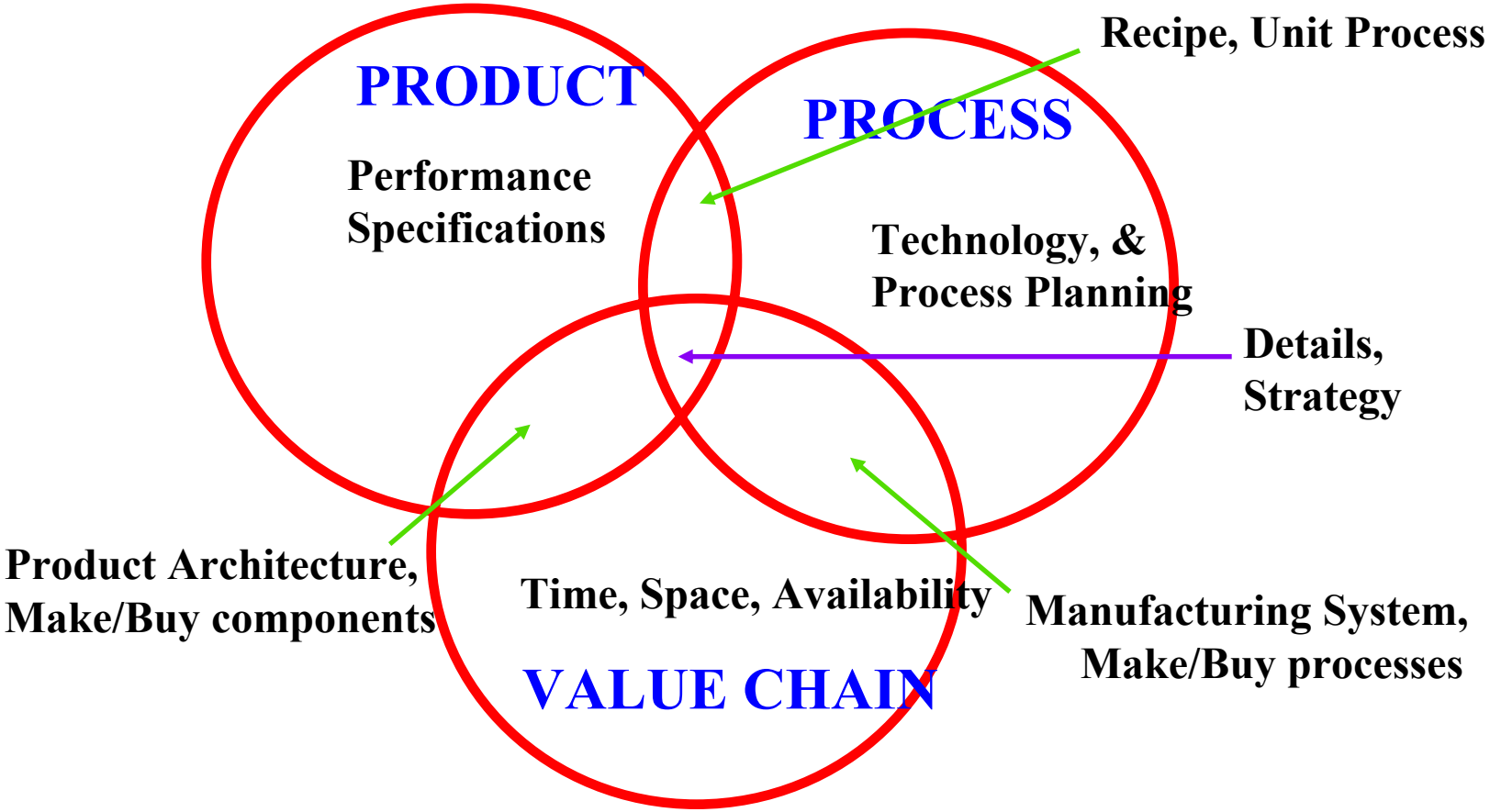
Clockspeed drives *Business Strategy Cadence*

Dynamics between New Projects and Core Capability Development: PROJECTS MUST MAKE MONEY AND BUILD CAPABILITIES



See Leonard-Barton, D. *Wellsprings of Knowledge*

IMPLEMENTATION OF VALUE CHAIN DESIGN: EMBED IT IN 3-D CONCURRENT ENGINEERING



ARCHITECTURES IN 3-D
INTEGRALITY VS. *MODULARITY*

Integral product architectures **feature**
close coupling among the elements

- **Elements perform many functions**
- **Elements are in close spacial proximity**
- **Elements are tightly synchronized**

- **Ex: jet engine, airplane wing, microprocessor**

Modular product architectures **feature**
separation among the elements

- **Elements are interchangeable**
- **Elements are individually upgradeable**
- **Element interfaces are standardized**
- **System failures can be localized**

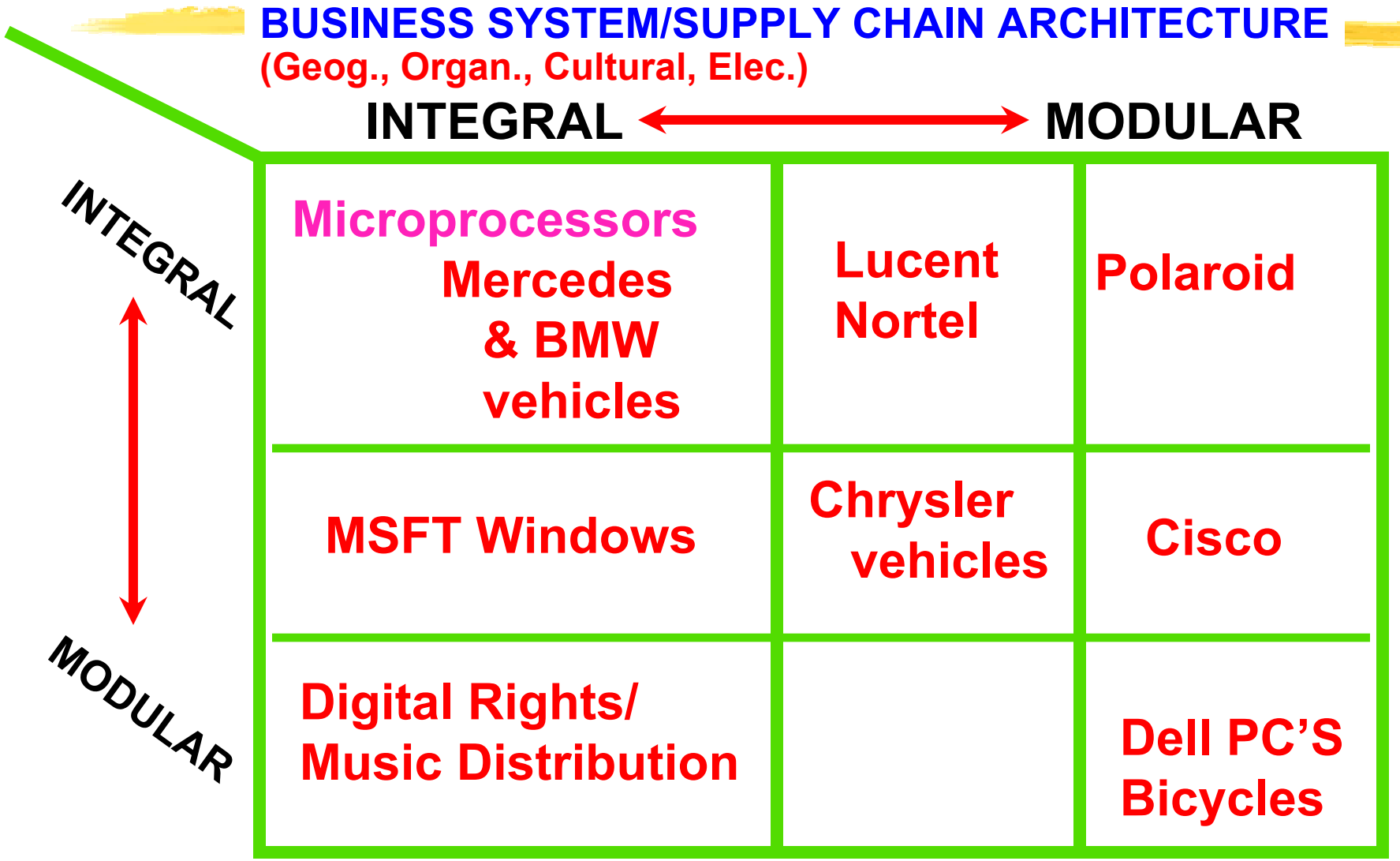
- **Ex: stereo system, desktop PC, bicycle**

VALUE CHAIN ARCHITECTURE

Integral value-chain architecture
features close proximity among its elements
- Proximity metrics: Geographic, Organizational
Cultural, Electronic
- **Example: Toyota city**
- **Example: Ma Bell (AT&T in New Jersey)**
- **Example: IBM mainframes & Hudson River Valley**

Modular value-chain architecture features multiple, interchangeable supplier and standard interfaces
- **Example: Garment industry**
- **Example: PC industry**
- **Example: General Motors' global sourcing**
- **Example: Telephones and telephone service**

ALIGNING ARCHITECTURES: BUSINESS SYSTEMS & TECHNOLOGICAL SYSTEMS



OPTICAL TELECOM VALUE CHAIN:
MINI CASE EXAMPLE

NORTEL NETWORKS plays at at least three levels of the Optical Network Telecom value chain:

1. Network design & installation
2. Modules (OC-192 network elements)
3. Components (lasers, amplifiers)

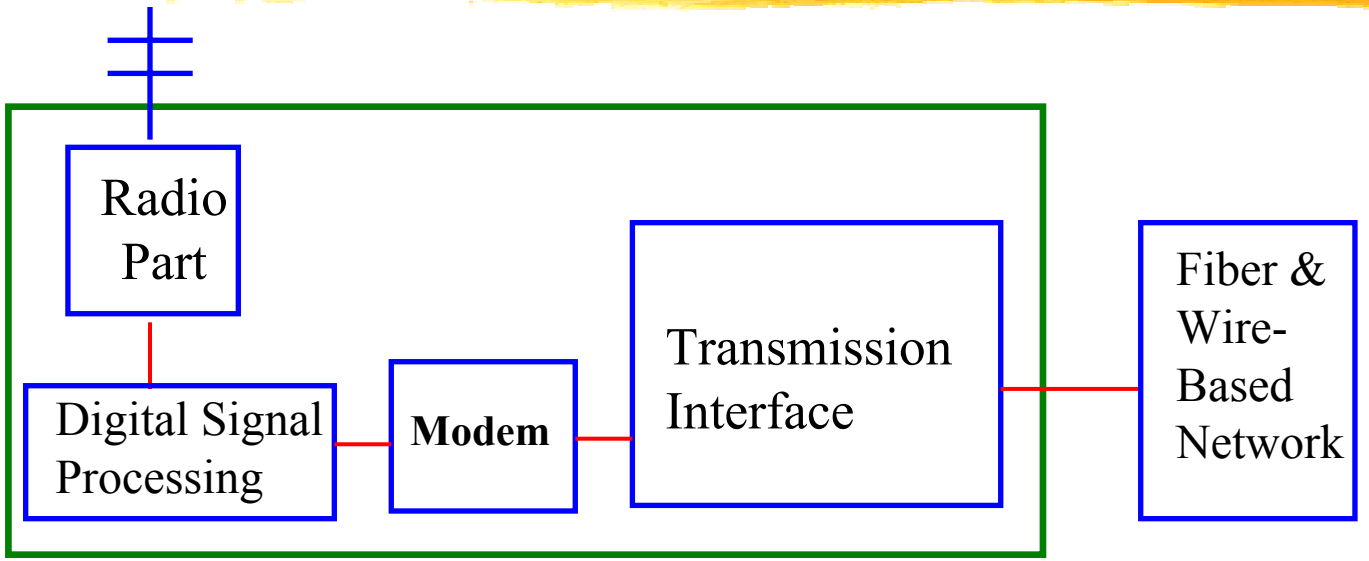
QUIZ: Should Nortel sell their components business?

Hint: How likely are the scenarios of:

- An *Intel Inside* effect in components?
- Networks become sufficiently modular as to be assembled by the customer?

WIRELESS VALUE CHAIN: MINI CASE EXAMPLE

Wireless Base Stations (WSB'S) comprise 4 key subsystems:



WSB architectures are
-integral & proprietary
Suppliers include: Nortel, Moto, Ericsson, Siemens, Nokia
Disruptive Modem advances (e.g., MUD) can double Base Station Capacity

Modular WSB's might
(1) Stimulate new WSB entrants (ala Dell)
(2) Stimulate standard subsystem suppliers
(3) lower prices to the network operators
(4) Speed base station performance imp.
(5) Increase demand for basestations due to improved price-performance ratios.

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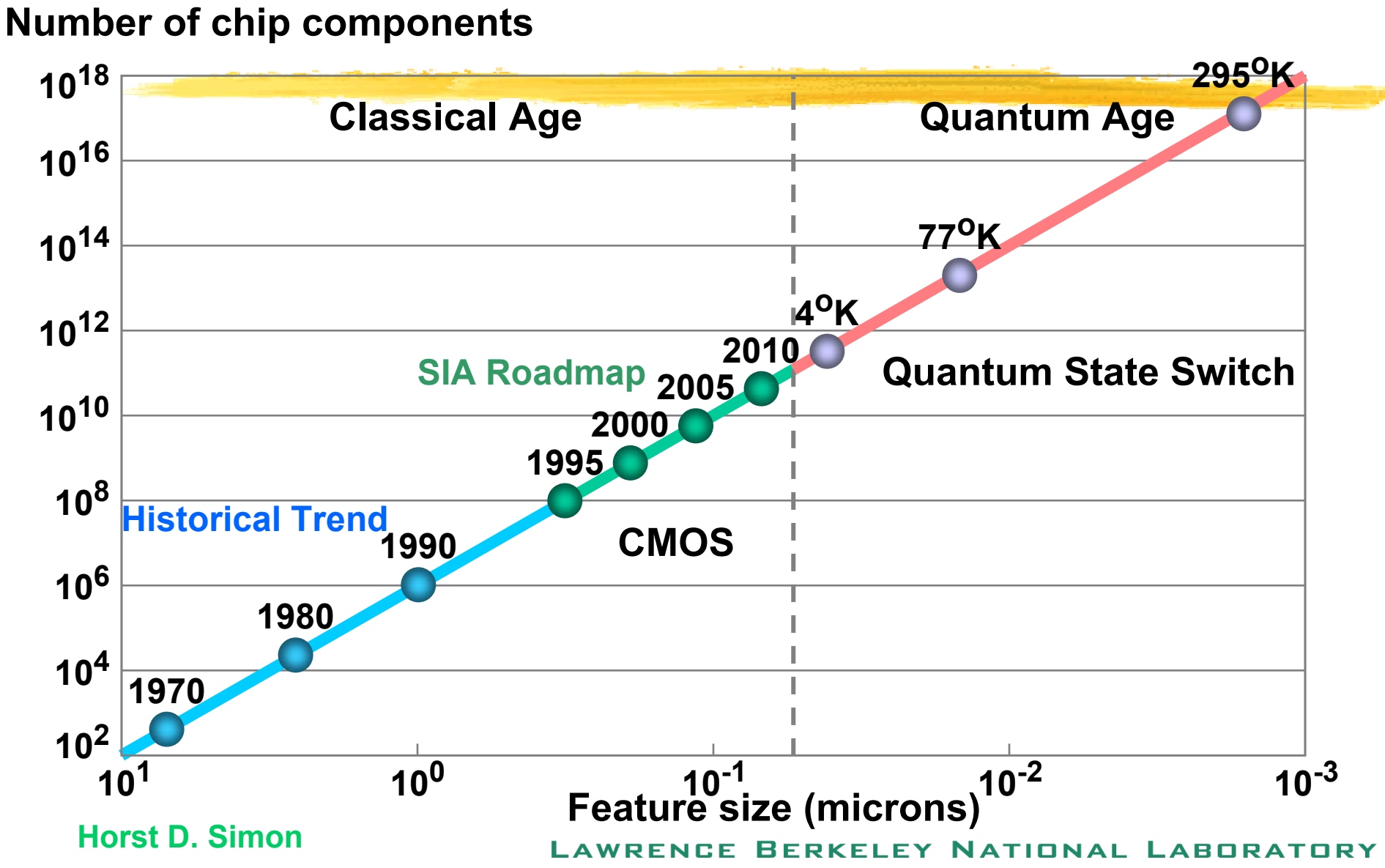
Roadmap for Electronic Devices

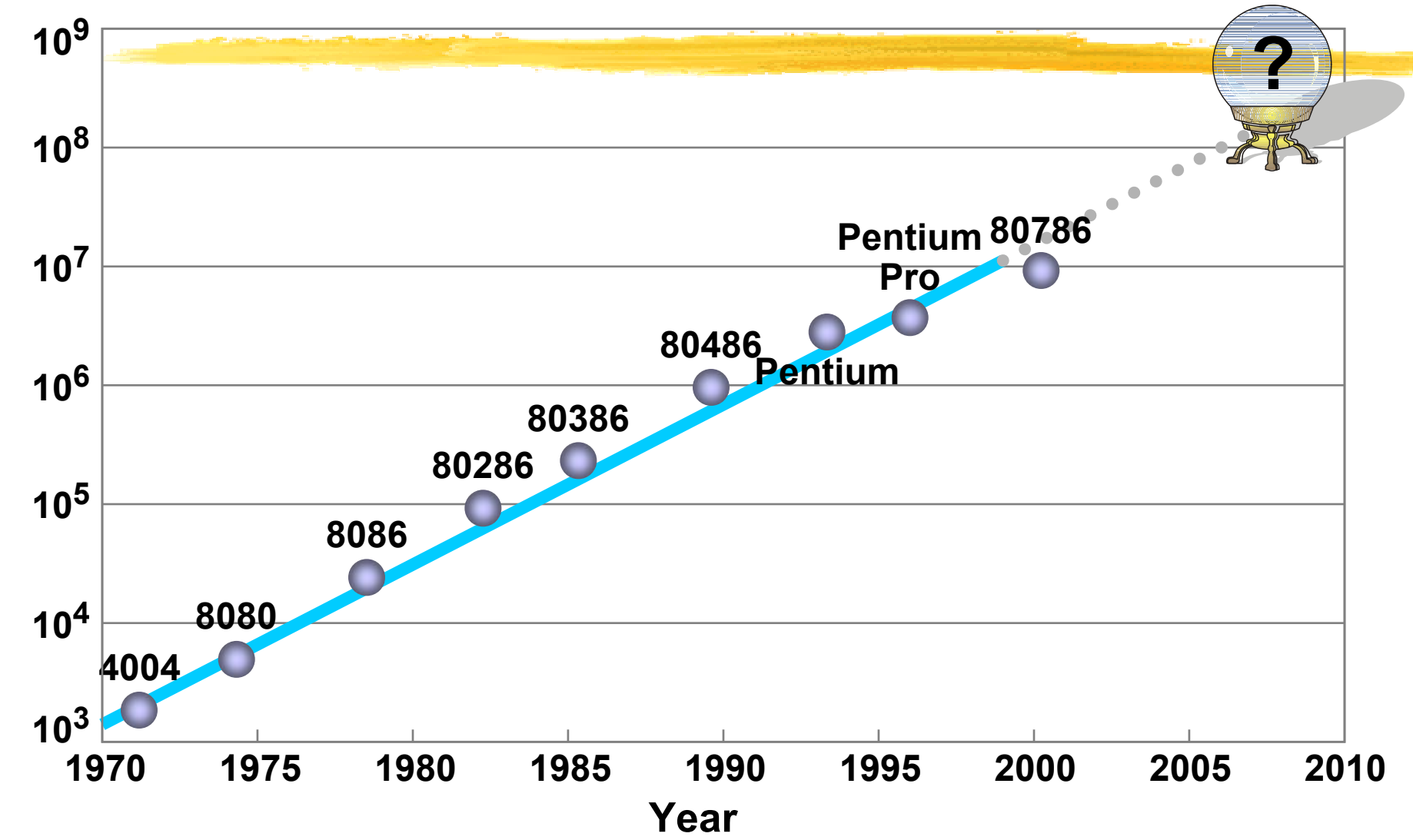


Horst D. Simon
LAWRENCE BERKELEY NATIONAL LABORATORY

International Technology Roadmap for Semiconductors '99

Year	2005	2008	2011	2014
Technology (nm)	100	70	50	35
DRAM chip area (mm^2)	526	603	691	792
DRAM capacity (Gb)	8		64	
MPU chip area (mm^2)	622	713	817	937
MPU transistors ($x10^9$)	0.9	2.5	7.0	20.0
MPU Clock Rate (GHz)	3.5	6.0	10.0	13.5

Moore's Law



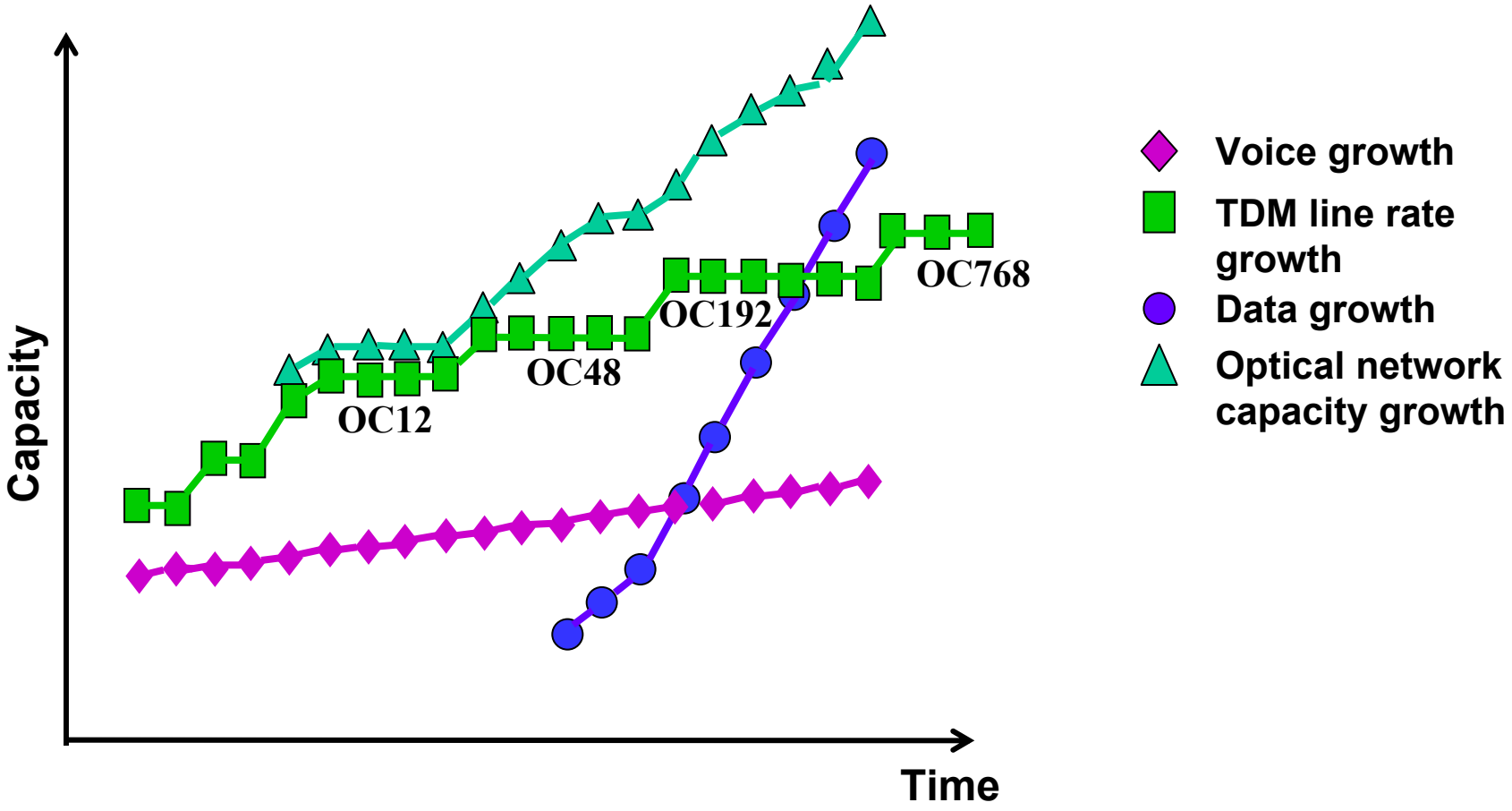
Source: Joel Birnbaum, HP, Lecture at APS Centennial, Atlanta, 1999

Disk Drive Development 1978-1991

Disk Drive Generation	Dominant Producer	Dominant Usage	Approx cost per Megabyte
14”	IBM	mainframe	$750
8”	Quantum	Mini-computer	$100
5.25”	Seagate	Desktop PC	$30
3.5”	Conner	Portable PC	$7
2.5”	Conner	Notebook PC	$2

From 1991-98, Disk Drive storage density increased by 60%/year while semiconductor density grew ~50%/year. Disk Drive cost per megabyte in 1997 was ~ $ .10

Optical Networking is Keeping Up!



"Killer Technologies" of the Information Age: Semiconductors, Magnetic Memory, Optoelectronics

"We define a *'killer technology'* as one that delivers enhanced systems performance of a factor of at least a hundred-fold per decade."

C.H.Fine & L.K. Kimerling, "Biography of a Killer Technology: Optoelectronics Drives Industrial Growth with the Speed of Light," published in 1997 by the Optoelectronics Industry Develoment Association, 2010 Mass Ave, NW, Suite 200, Wash. DC 20036-1023.

Killer Question:

Will *Integrated Optics* evolve linearly like Semiconductors with Moore's Law or like Disk Drives with repeated industry disruptions?

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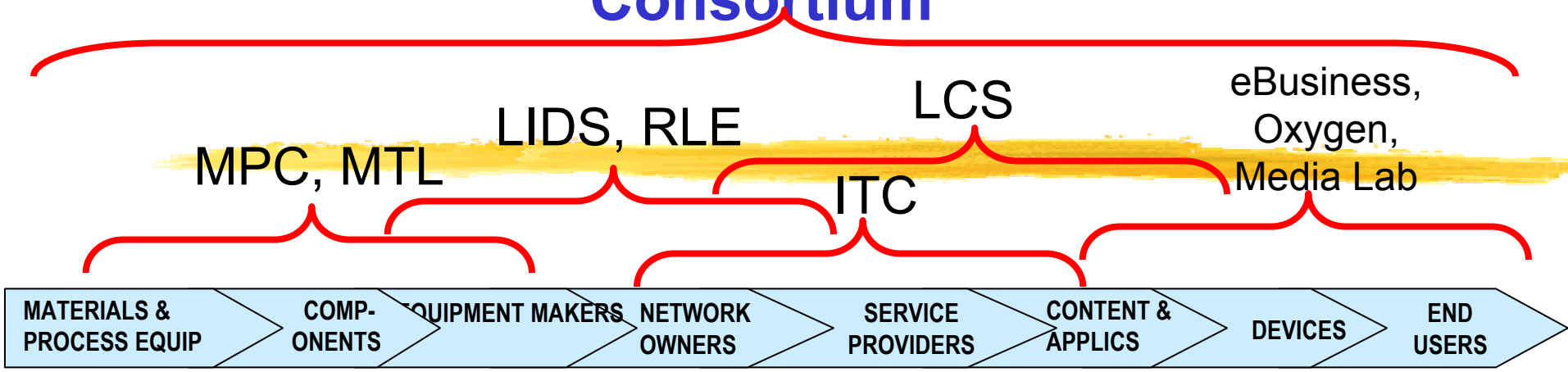

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Access Architecture

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All Conclusions are *Temporary*

Clockspeeds are increasing almost everywhere
Value Chains are changing rapidly